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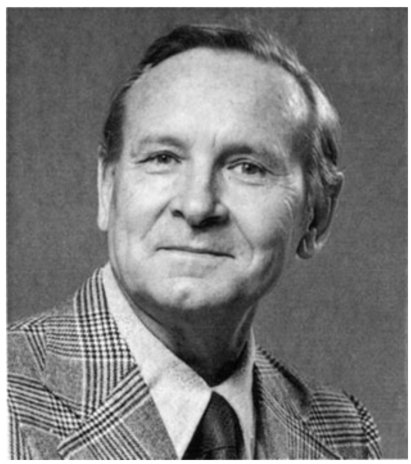
Otoplastic Architecture

LESLIE G. FARKAS



In the practice of plastic surgery, special ear examinations are carried out for:

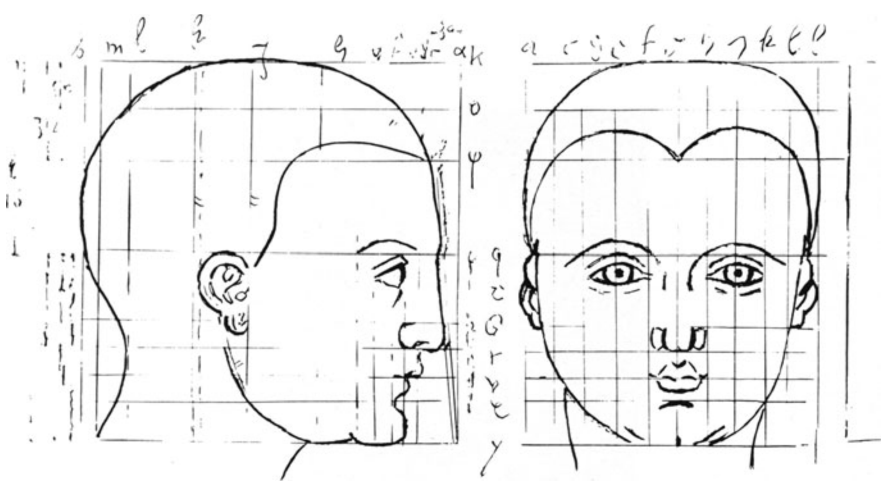
Diagnosis, to determine the morphological ear changes in congenitally defective or traumatically damaged cases.
Therapy, to establish the quality and extent of the defect in order to plan surgical repair. Further ear examinations after surgery are necessary to evaluate progress and results.

The special features of these examinations are:

1. Evaluation of the auricular morphological defect in relation to the rest of the head and face, with *objective methods,* based on measurements between well-defined landmarks on the surface of the head and face, in order to establish the degree of aberration from the normal. Measurements of a healthy population identical with those of the patient are required for comparison.

J. Davis, *Aesthetic and Reconstructive Otoplasty*

2. Establishment of *proportions* between ear size and the craniofacial complex, as well as determining the relationship between ear width and length. Proportions of the head and face were studied by artists of antiquity (Polycleitus) and the Renaissance (Francesca, da Vinci, Dürer), and their views have influenced generations of artists and anatomists. In modern anthropometry (Martin and Saller, 1957, 1962), the relationship between two related measurements is given in the form of an *index* in which the smaller measurement (numerator) is expressed as a percentage of the greater (denominator).



Proportions of the head and face (Dürer, 1471–1528)

3. Determination of the rate of *growth* in a face or ear. If surgery is carried out upon a developing face, the growth pattern is as important as the early surgical improvement. Preoperative knowledge of the growth rate is imperative in order to judge surgery on a developing organ. A delay in growth of the operated area can finally detract from a good early result.

Methods of Examination

Anthroposcopy

Anthroposcopy, or visual assessment, practiced since the very beginning of the medical profession, is *subjective* and requires a great deal of experience. Thus shape deformities, asymmetries, and disproportionate features are observed, but judgment of length and width measurements, or angles, by vision only is inaccurate. Judgment is very much influenced by the aesthetic sense of the examiner, his criterion for accuracy, his attention during the examination, and even his psychological state at that moment. Different examiners will "see" differently. Powers of observation can vary greatly from one to another and improve with training. But visual assessment is difficult to describe precisely in the medical history and still more difficult to remember some time later, to compare progress and results. Occasionally, only visual examination of the facial features can suffice, as when evaluating a general effect of surgery.

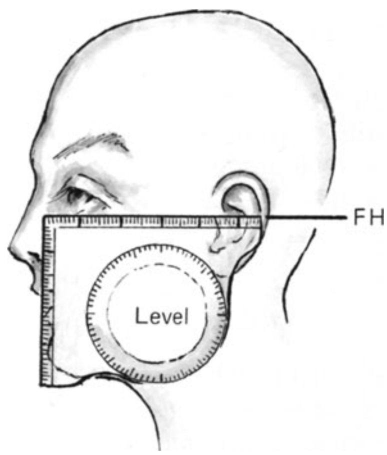
Anthropometry

Anthropometry of physical anthropology is more accurate and reliable. It is a collective name for all *methods of measuring* the human body surface. The main surface measurements of the face and head (length of skull, length of face, length of ears, and so forth) have been well described and performed with uniform techniques (Godycki, 1956; Martin and Saller, 1957, 1962; Weiner and Lourie, 1969). Other measurements (ear protrusion, inclination of the long ear axis, ear level, for example) have, however, been carried out by different authors using varied methods, and therefore the data compiled is difficult to compare (Tanzer, 1974a). This unfavorable situation became even more complicated with the introduction of new measurements (ear canal location in the horizontal and vertical planes, for example) or modifications of old ones to satisfy surgeons' increasing interest in the subject. There was some difficulty in defining the significant differences between these methods. Data was limited, and few studies have been recently devoted to this subject. These circumstances encouraged us to carry out an extensive facial study (Farkas, 1981). On the basis of this study, we can recommend the following approach to ear examination.

Conducting Examinations

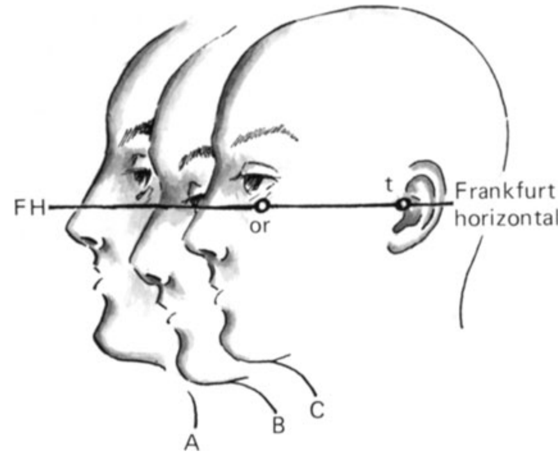
Conditions for Ear Examination

The *light* must be sufficiently strong to see the finest details of the face and ears. The examined person should *sit* in a chair with supports for the head, back, and arms and with an adjustable seat. The examiner's head should be on the same *level* as that of the patient, to avoid distortion of the examined face caused by viewing from above or below.



Frankfurt horizontal, maintained with a commercial level finder, or angle meter.

Some measurements of the face and ears require a *standard position* of the head. In this position the head is oriented in the Frankfurt horizontal (FH), defined by a line connecting the orbitale (the lowest point of the infraorbital margin) and the porion (point at the upper edge of the auditory meatus) or tragion (landmark on the upper edge of the tragus) of the ear, maintained horizontal with the help of a commercial angle meter. The standard position must be rechecked at each measurement. The head of a noncooperative person is held by an assistant. In our normal facial study, we found that the FH is not always on the same level on both sides. Usually the left side was, on average, 4.1 degrees lower in boys and 3.9 degrees in girls. This difference of levels can explain some asymmetries in lateral facial measurements. In patients with evident dislocation of one orbit, the differences of ear measurements (ear level and inclination, vertex–porion distance, opisthion–porion distance, etc.) were even more apparent. In these patients the standard position of the head is established according to the FH of the less defective side.



Various "rest positions" of the head—5 degrees above the FH in A, 5 degrees below in B—in relation to correct FH as shown in C.

Measurements not influenced by position of the head are made with the subject's head in the *rest position.* This is determined by the patient's own feeling of the natural head balance (Solow and Tallgren, 1971). In healthy persons in the rest position, the FH is about 5 degrees below the line connecting the orbitale and the porion (Farkas, 1981). To establish the ear position vertically, the subject's profile line must also be vertical. This is defined by three anatomic points: the nasal root (nasion), the columella base (subnasale), and the lowest mandibular edge (gnathion or menton). Vertical positioning of the facial profile is difficult if the facial midpoints are not located in the midaxis of the face.

In faces with congenitally affected ear(s) it is recommended to determine the actual difference between the rest and standard positions of the head. In everyday life the ears are seen in rest positions of the head, but their true position can be established only in the standard FH position as illustrated.

Accuracy of measurements depends on the experience of the examiner with these techniques. Correct identification of landmarks and the proper use of measuring tools, barely touching the skin surface, are basic requirements for precise examination. It is advisable to mark the points of identification very carefully on the skin. Thus, the point on a bifid tragus must be marked where the tragion should be. The margin of error is greatly reduced if the measurements are carried out by the same person, in a group of people, and repeatedly.

Landmarks of the Head, Face, and Ear

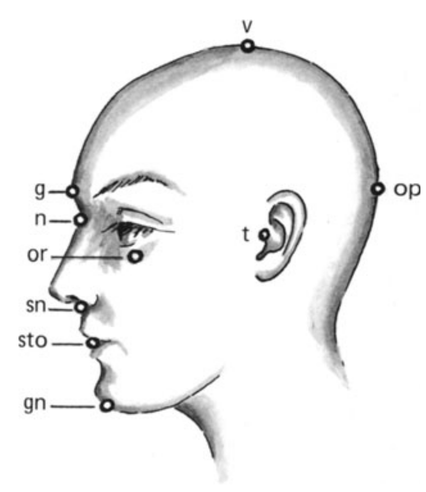
Routine classical physical anthropological landmarks as used in our study (Godycki, 1956; Martin and Saller, 1957, 1962) are the points from which measurements are taken.

Head Landmarks

Vertex (v). The highest point of the head, in the FH.
Glabella (g). The most prominent point in the midline between the two eyebrow ridges, a little (about 10 mm) above the nasion (see below).
Opisthion (op). The most posterior point of the head, an anatomically indefinite landmark localized at the end of the horizontal drawn from the glabella.

Facial Landmarks

Nasion (n). The midline point of the nasofrontal suture (nasal root). It can be identified by palpation or by the midline of a horizontal connecting the right sulcus palpebralis superior with the left one.
Subnasale (sn). The midline point of the columella base.
Stomion (sto). The point of the facial midline between gently closed lips.
Menton or gnathion (gn). The lowest median landmark on the lower mandibular border, identified by palpation.
Orbitale (or). Lowest point of the inferior orbital rim.

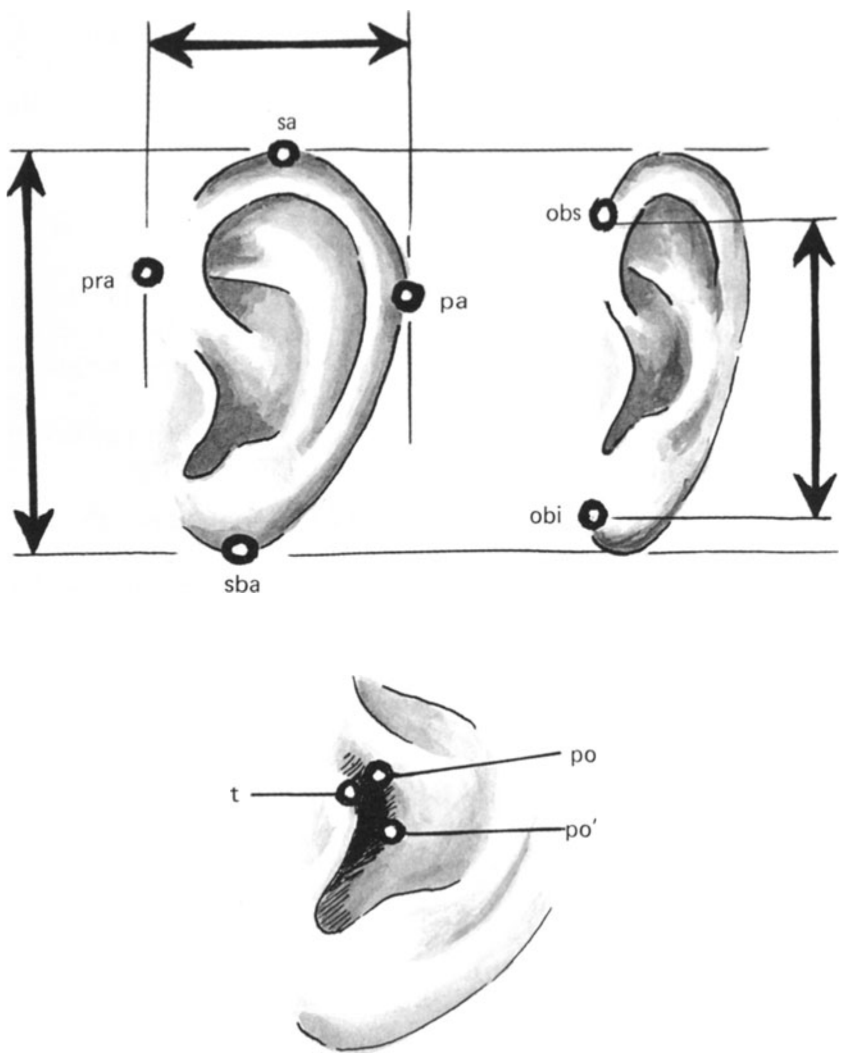


Surface landmarks of the face and head. Farkas LG (1978) Anthropometry of normal and anomalous ears. In: Furnas D (ed) Clinics in Plastic Surgery, Philadelphia: W.B. Saunders Co., v. 5, p. 402, reprinted by permission.

Ear Landmarks

The reference points around the auricle are:

Supra-aurale (sa). The highest point of the free helical periphery.
Subaurale (sba). The lowest point of the free lobular periphery.
Preaurale (pra). The most anterior point of the ear, located just in front of the helical attachment to the head.



Top: reference points at the auricle, with length, width, and attachment point measurements. Bottom: landmarks around the external auditory meatus. Reproduced with permission from Farkas LG, Growth of normal and reconstructed auricles. In Tanzer RC and Edgerton MT (eds.), Symposium on Reconstruction of the Auricle, St. Louis, 1974, The C.V. Mosby Co.

Postaurale (pa). The most posterior point of the free helical periphery.
Otobasion superius (obs). The attachment point of the helix in the temporal area.
Otobasion inferius (obi). The attachment point of the lobe to the cheek.

Three important parameters using these landmarks are shown in the above figure: height or length (sa–sba), width (pra–pa), and insertion distance (the morphological width of the ear: obs–obi).

The reference points around the external auditory meatus are:

Tragion (t). The notch immediately above the tragus. The shape of the tragus varies and can be triangular, trapezoidal, or bifid.
Porion (po). The highest point of the external auditory meatus.
Posterior edge of the meatus (po').

Landmark Determination

Bony landmarks (orbitale, nasion, gnathion, etc.) should be located by palpation. Missing landmarks are replaced by other references of the facial surface (Farkas, 1981). Identified points are marked with ink on the skin surface.

In congenital anomalies of the face associated with ear defects, the following landmarks may be dislocated or missing:

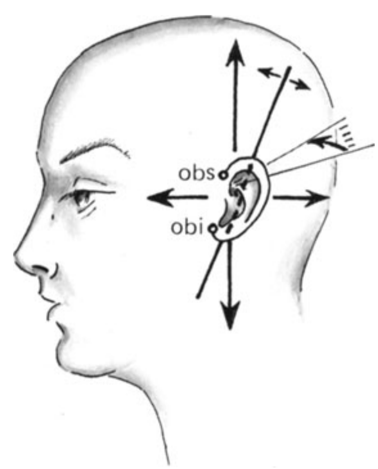
1. If the frontal nasal suture line cannot be palpated, the *nasal root* can be determined by the level of the sulci palpebrales superiores. In some severe facial deformities, the nasal root may be deviated to one side.
2. The *columella base* is often dislocated toward the unbalanced side of the face. The extent of dislocation must be determined from the ideal midline of the face.
3. The true *labial commissure* is missing if the mouth is split by a lateral cleft. This defect is often associated with an oblique direction of the labial fissure. The real location of the commissure can be identified by the remnants of vermilion in the labial portion, while the cleft part of the cheek is bordered by buccal mucosa.
4. A missing *tragus* can be replaced by the point located on the anterior border of the auditory meatus if present.
5. If the *external auditory meatus* is atretic, the point palpated just behind the temporomandibular joint may replace it. This substitute is not ideal, however, and serves only as a subsidiary reference point. The same point can be used to replace the tragion.
6. The *chin point* may be off-centered in severe asymmetries of the face. Again, assessment of the deviation from the ideal midline of the face is required.

Ear Geography

Geography is the relationship between the ear and the neighboring facial features, such as the eyebrows, eyes, nose, upper lip, and mandible. It is determined by (1) location, (2) level, (3) inclination, and (4) protrusion. To assess auricular geography with maximum accuracy, more than one method is applied in some measurements.

First, it is necessary to establish whether the facial features to be used as guides are normally developed and located. This can be done by visual examination and some basic measurements. Some relationships of ear geography are determined quantitatively, others qualitatively only. All measurements are carried out on both sides.

1. *Ear location* is defined by vertical and horizontal planes, relating the ear position to (a) the facial midline landmarks, (b) the apex of the head (vertex), and (c) the backpoint of the head (opisthion). Measurements are carried out between the following points:



Geography: Orientation of the ear toward other features (location, level, inclination, protrusion). Farkas, LG (1978) Anthropometry of normal and anomalous ears. In: Furnas D (ed), Clinics in Plastic Surgery, Philadelphia: W.B. Saunders Co., v. 5, p. 404, reprinted by permission.

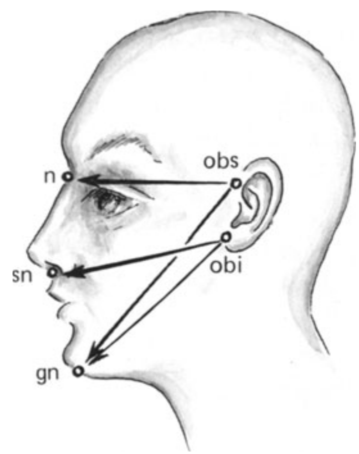
a. *Face-ear* (Figalová and Farkas, 1968). These measurements do not require the orientation of the head in the FH. The examinations are carried out with a spreading caliper.

i. Projected distance between nasion (n) and otobasion superius (obs).

ii. Projected distance between subnasale (sn) and otobasion inferius (obi).

iii. Projected distance between menton or gnathion (gn) and otobasion superius (obs).

iv. Projected distance between the chin (gn) and the lower ear insertion (obi).

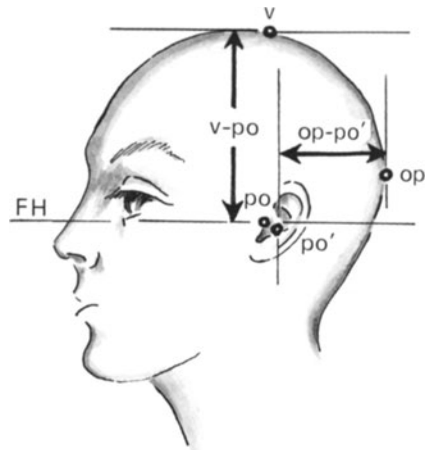


Projective face-ear location measurements of the ear's insertion points (obs, obi) from the facial midline landmarks (n, sn, and gn). Reproduced with permission from Farkas, LG, Growth of normal and reconstructed auricles. In Tanzer RC and Edgerton MT (eds.), Symposium on Reconstruction of the Auricle, St. Louis, 1974, The C.V. Mosby Co.

b. *Head-ear.* During these examinations, the head must be in FH, and the measurements are taken with a modified sliding caliper (Farkas, 1981). The Frankfurt plane for each side must be established individually because of possible differences.

i. Vertical rectilinear distance between the projected vertex (v) and the upper edge of the external auditory meatus (po).

ii. Horizontal rectilinear distance between the projected back point of the head (op) and posterior edge of the external auditory meatus (po').

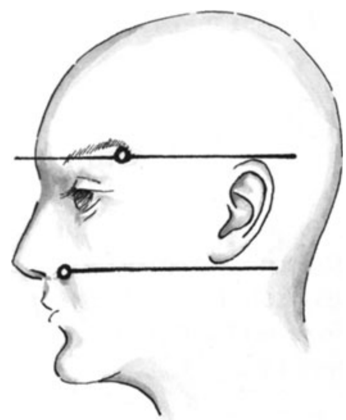


Projected head-ear location measurements of the auricular canal (po and po'), from the superior (v) and posterior (op) points of the head. From Farkas, LG (1978): Anthropometry of normal and anomalous ears. In: Furnas D (ed), Clinics in Plastic Surgery, Philadelphia: W.B. Saunders Co., v. 5, p. 403–404, reprinted by permission.

2. *Ear level* is determined by three references:
   a. Assessing the *tragi* only visually by their mutual position in the horizontal plane. The notches above the tragi are marked with ink, and the head is oriented in the FH with the facial profile line in a vertical position. The examiner must stand in front of the subject and judge the tragi location with the aid of two rods gently pressed on the tragi marks. This examination serves only for rough positioning of the tragi level, and thus the ears. The result of this examination is recorded either as "tragi on the same level" or "asymmetrical in level" (the side of the lower located tragus is recorded in the chart).

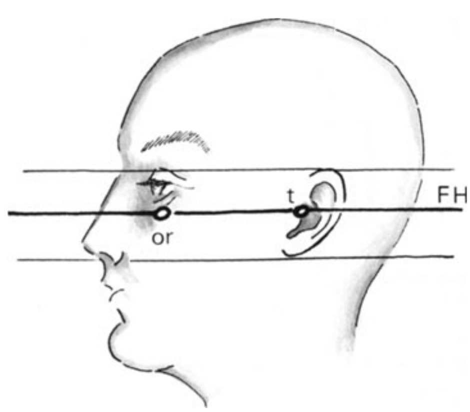
Relative position of the two tragions, assessed by holding the rods horizontally. Farkas, LG (1978) Anthropometry of normal and anomalous ears. In: Furnas D (ed) Clinics in Plastic Surgery, Philadelphia: W.B. Saunders Co., v. 5, p. 403, reprinted by permission.

b. Assessing the vertical ear position, by relating *the upper and lower ear edges* to the eyebrow and nasal ala upper lip level. The result of the examination depends very much on the correct orientation of the head in FH. Positioning the ear by reference to the eyebrow and nasal ala is a few centuries old and has been accepted by some anatomists (Henle, 1873).



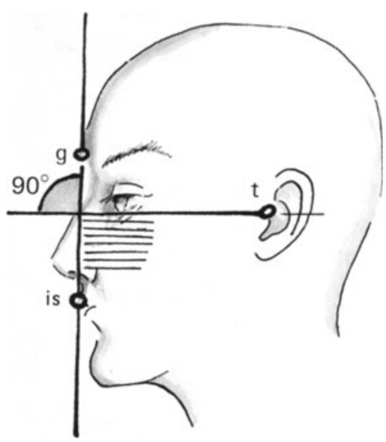
With the head in the position of "rest," the upper edge of the ear is on a level with the eyebrow and the lower with the nasal ala (Henle, 1873).

We carry out this examination by placing, with one hand, a thin rod along the points marking the FH. A second rod we hold with the other hand, first at the upper and then at the lower ear edges, parallel to the previous rod. Thus, we are able to define the true location of the ear edges in relation to the orbital area, the nasal ala, and the upper lip.

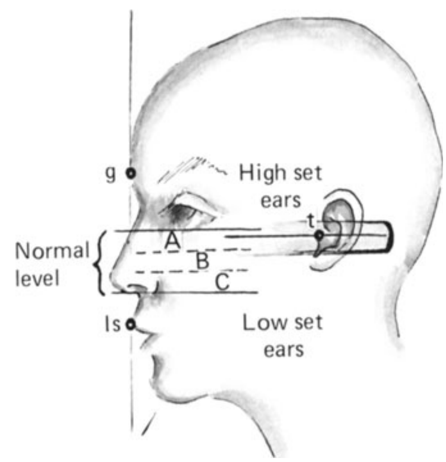


This ear's upper edge is at the level of the upper lid, and the lower ear edge levels with the ala nasi. The examination is carried out with the head positioned in FH. Farkas, LG (1978) Anthropometry of normal and anomalous ears. In: Furnas D (ed) Clinics in Plastic Surgery, Philadelphia: W.B. Saunders Co., v. 5, p. 403, reprinted by permission.

c. *Assessing the ear level according to the position of the ear canal* in relation to the middle face gives more objective findings about the true vertical ear location than the previous examinations. This method was described by Leiber in 1972, and we use it routinely in a slightly modified version. We have constructed a simple instrument to make the measurement easier. The perpendicular part of the instrument is pressed gently on the facial profile at the glabella and at the most protruded point of the upper lip, with the lips in closed position, while the other part with the black line in the horizontal branch must reach the point on the tragus, marked with ink. With the instrument thus held, the black line on the horizontal branch shows the level of the ear canal. Normally this should fall between the free margin of the lower eyelid and the nasal ala. If the horizontal branch line crosses the area above the orbitale, the ear canal is in a "high" posi-

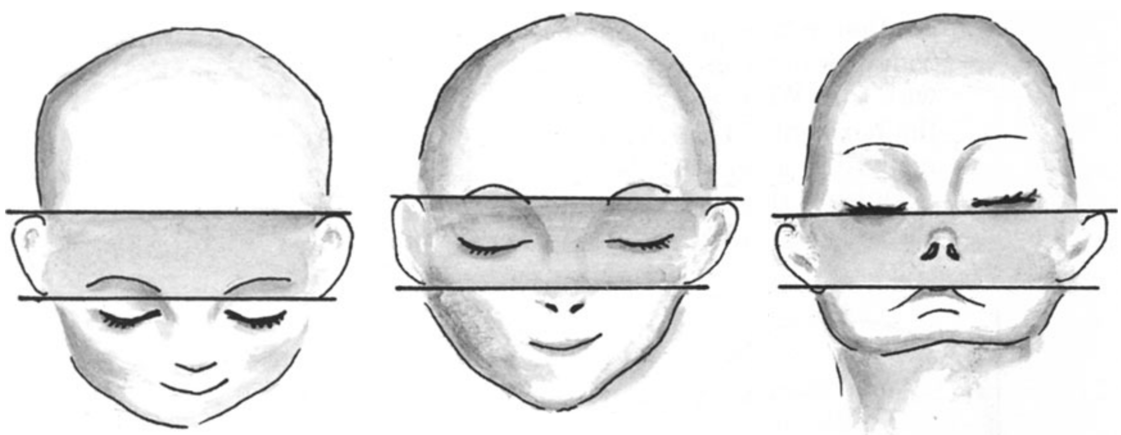


Modified method of Leiber (1972) to locate ear level according to the ear canal. The solid lines represent the main branches of the special instrument, which is a vertical ruler with a sliding horizontal shaft. The lined area is normal level location. In this drawing, the canal is located at the ceiling of the normal area. Farkas, LG (1981) Anthropometry of the head and face in medicine. New York: Elsevier, p. 57. Reprinted by permission.



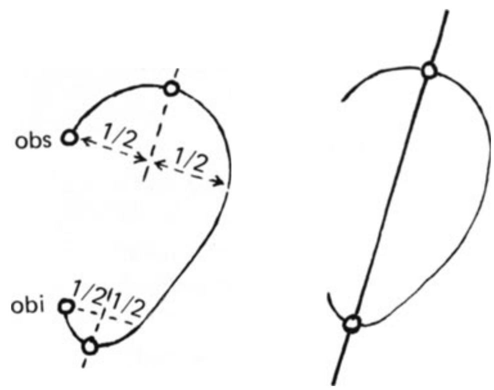
The method of identifying ear canal location as modified by us for greater precision, by dividing it into three equal segments: A, B, and C. The measuring line of the horizontal shaft of the instrument is placed on the tragion (t), and the vertical shaft touches the glabella (g) and the most protruding point of the upper lip (ls). In this case the measuring line falls into segment A, showing the ear to be at a high normal level. Farkas, LG (1978) Anthropometry of normal and anomalous ears. In: Furnas D (ed.) Clinics in Plastic Surgery, Philadelphia: W.B. Saunders Co., v. 5, p. 403; and vertical location of the ear assessed by the Leiber test, in healthy North American Caucasian 6 to 19 years of age. Arch. Otorhinolaryngol., 220:9, 1978, reprinted by permission.

tion; and if it does so below the nasal ala, the canal is in a "low" position (Farkas, 1978c). Definition of the "low set" ear varies from one observer to another (Feingold and Bossert, 1974), and it is seldom done with the head in FH. We wish to emphasize that this feature may be inaccurate by visual examination only, and the common recording of low set ears in facial syndromes can be explained by this fact.

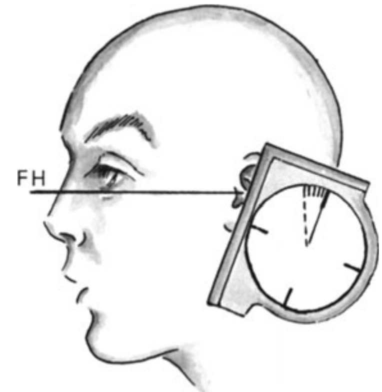


The perspective illusion of changing auricular level, simply from raising and lowering the chin, illustrating the importance of referring to the FH (middle face) for precision. Farkas LG (1981) Anthropometry of the head and face in medicine. New York: Elsevier, p. 48. Reprinted by permission.

3. *Ear inclination* is expressed in degrees and indicates the pinna slant in relation to the vertical. The measurement is carried out with the head in FH. The inclination is determined separately for each ear. The medial longitudinal pinna axis should be traced and is the imaginary rectilinear line along the middle of the ear, connecting two points on opposite poles of it (Farkas, 1974, 1978a, 1978c). The superior point is obtained by halving the upper portion of the ear, and the inferior point is the middle of the lobule's free border. When measuring the inclination, the long side of the angle meter is placed along the line connecting the two most remote landmarks of the medial axis.

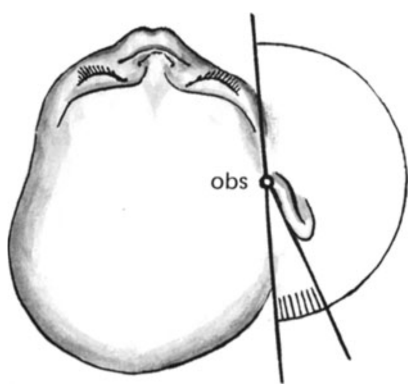


Establishing inclination by defining the longitudinal axis by halving the dome and lobule (Farkas, 1978c).



The longitudinal axis is measured from the vertical, with a level and angle finder (Farkas, 1981). Reproduced with permission from Farkas LG, Growth of normal and reconstructed auricles. In Tanzer RC and Edgerton MT (eds.), Symposium on Reconstruction of the Auricle, St. Louis, 1974, The C.V. Mosby Co.

4. *Ear protrusion* is the acute angle between the posteromedial aspect of the auricle and the mastoid plane of the head, measured with a transparent protractor (Farkas, 1974). The protractor is held in a horizontal plane and centered with its "0" pressed above the ear's upper insertion point. An ear protruding over 40 degrees is considered "prominent."

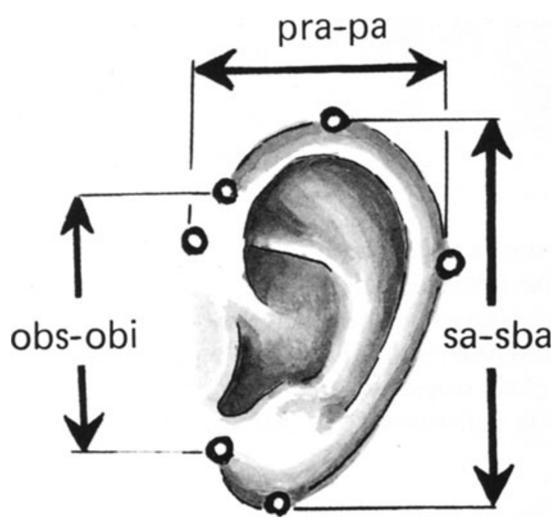


Measurement of ear protrusion by placing a transparent protractor with the zero point over the upper insertion point (obs). Farkas LG (1981) Anthropometry of the head and face in medicine. New York: Elsevier, p. 47. Reprinted by permission.

Ear Size

Assessment of ear size belongs to basic anthropometric examinations.

1. *Ear length* is the rectilinear distance between the highest (sa) and lowest (sba) points of the auricle, measured with a sliding caliper.
2. *Ear width* is the rectilinear distance between the most anterior helical insertion (pra) and the most posterior point of the helical periphery (pa), measured with a sliding caliper.
3. *Ear length of attachment* (the morphological width of the ear) to the head is the rectilinear distance between the ear's upper (obs) and lower (obi) insertion points, measured by a sliding caliper.



Length, width, and attachment measurements. Reproduced with permission from Farkas LG, Growth of normal and reconstructed auricles. In: Tanzer RC and Edgerton MT (eds.), Symposium on Reconstruction of the Auricle, St. Louis, 1974, the C.V. Mosby Co.

Norms

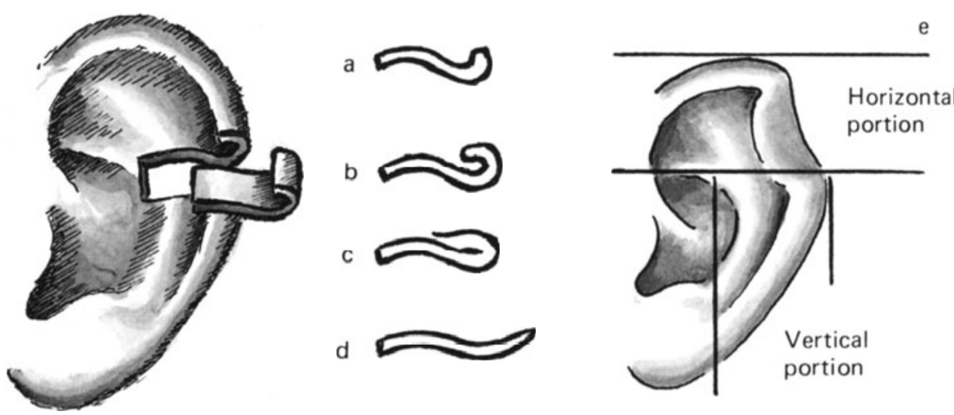
Our study also yielded normative data against which measurements from individual ear examinations can be evaluated (Tables 2.1–2.17).

Ear Qualitative Signs

In spite of our efforts in the facial study of healthy North Americans to replace subjective judgment of ear morphology as much as possible by measurements, some features of the ear had to be assessed only visually. This is because a large percentage of the population has ear variations. Among these anatomic irregularities, it is often difficult to determine which represent true developmental defects and which are only variations of the normal (Hrdlička, 1925).

According to D. W. Smith (1970), only the *unusual* morphological features with no serious medical or cosmetic consequences to the patient should be defined as minor anomalies (in the auricular area: cutaneous tags or pits, incompletely developed scapha or helix, absence of lobules, prominent ear, and low set ear). Variants of less importance, frequently found in the healthy population, should not be classified as minor anomalies.

The general shape we classified as "normal" or "abnormal." The abnormal auricle we termed *macacus* or *cercopithecus* in type, but any other unusual characteristic we also described. The helix we called (a) normally developed and rolled; (b) abnormally wide but not covering the scapha; (c) wide and thin and covering the scapha; (d) flat and unfolded; and (e) wide, having a concave impressionlike abnormality at the junction of the vertical and horizontal portions of the pinna. Lobe size we classified as "hypoplastic" or "well developed." The preauricular terrain was examined for skin appendages and pits.



Variations of the helical rim: (a) normal, (b) wide, (c) covering the scapha, (d) unfolded, and *(e) impression on the helical margin where the horizontal and vertical portions of the ear meet, causing a concave deformity which can compress the scapha (observed also in satyr ear). Farkas LG (1981) Anthropometry of the head and face in medicine. New York: Elsevier, p. 54–55. Reprinted by permission.*

Ear Quantitative Signs

We have established average values of ear measurements of healthy North American Caucasians of both sexes for three age groups: from 6 to 7 years, 12 to 13 years, and 18 to 19 years. This material represents part of the data we collected from 1,312 healthy North American Caucasians in three age groups spread over 6 to 19 years of age (Farkas, 1981). The reported findings in these three age groups, each separated by 6 years, assess growth of the auricle and should be enough for general conclusions.

Standard statistical methods (standard error of difference, SED; t-test) were applied for evaluation. On comparing the actual measurements of the patients with the normals, findings are normal if they fit into the range represented by 95 percent of the normal population, determined by the average value of measurement, minus two standard deviations below and plus two standard deviations above (mean $\pm$ 2 SD).

In reality, the span of normal range can vary from only a few millimeters (i.e., length between ear insertion points) to as much as 20–30 mm (i.e., maxillary and mandibular surface arcs). Borderline normal measurements are those which fall 0.5 mm or 0.5 degrees outside the normal range. Measurements distinctively outside of the normal range are classified as supernormal or subnormal (Hellman, 1939).

All linear measurements are in millimeters, and the angles are in degrees. The tables of this chapter give the average values ($\bar{x}$) and the standard deviations (SD) for each measurement and also the smallest ($\bar{x}$ − 2 SD) and largest ($\bar{x}$ + 2 SD) values of the normal range.

Ear Size. We have data about ear growth from birth until 5 years of age taken from the West German population (Hajniš, 1974) and from 6 to 18 years of age from the North American Caucasian population (Farkas, 1981). Ear measurements of older individuals are similar in corresponding age groups.

According to Hajniš (1971), ear size in both sexes is the same at birth. Growth averages 5.7 mm during the second half of the first year and 6 mm in the following 5-year period. At the beginning of the second year of life, ear growth slows down and at certain times is almost stagnant. In boys, this stagnancy occurs between 1 and 2 years, 3.5 and 4 years, 7 and 9 years, and 11.5 and 13.5 years. Auricular growth in girls is more regular, although a lag occurs in the second year (Hajniš and Dobisiková, 1968b).

Tables 2.1 and 2.2 show the average values of the left *ear length* in boys and girls from 6 months to 18 years of age, and the values of *ear width* are given in Tables 2.3–2.4. Lengthwise, ear growth was completed between 18 and 19 years of age in boys and one year earlier in girls.

TABLE 2.1. Length of left ear in healthy Caucasian males.

Population norm	*Age*	N	*Mean* ($\bar{x}$) (*mm*)	*SD*	*Range of normal* ($\bar{x}$ − 2 *SD*)–($\bar{x}$ + 2 *SD*)
German	6 mo	18	47.5	3.4	40.7–54.3
(Hajniš, 1974)	1 yr	27	48.8	2.5	43.8–53.8
	2	32	52.4	3.1	46.2–58.6
	3	55	51.8	3.4	45.0–58.6
	4	77	54.7	3.5	47.7–61.7
	5	70	55.2	3.3	48.6–61.8
North American Caucasian	6 yr	50	55.0	2.9	49.2–60.8
(Farkas, 1981)	7	50	55.0	3.7	47.6–62.4
	8	51	56.7	3.2	50.3–63.1
	9	51	57.3	3.5	50.3–64.3
	10	50	58.6	3.1	52.4–64.8
	11	50	58.7	3.7	51.3–66.1
	12	52	59.1	3.6	51.9–66.3
	13	50	61.0	4.0	53.0–69.0
	14	49	61.0	3.7	53.6–68.4
	15	50	62.4	2.9	56.6–68.2
	16	50	61.4	4.0	53.4–69.4
	17	49	62.0	4.1	53.8–70.2
	18	52	62.4	3.7	55.0–69.8

TABLE 2.2. Length of left ear in healthy Caucasian females.

Population norm	*Age*	N	*Mean* ($\bar{x}$) (*mm*)	*SD*	*Range of normal* ($\bar{x}$ − 2 *SD*)–($\bar{x}$ + 2 *SD*)
German	6 mo	29	45.8	3.8	38.2–53.4
(Hajniš, 1974)	1 yr	25	48.7	3.1	42.5–54.9
	2	28	51.1	3.0	45.1–57.1
	3	47	51.1	2.9	45.3–56.9
	4	66	52.5	3.3	45.9–59.1
	5	69	53.1	3.3	46.5–59.7
North American Caucasian	6 yr	50	54.2	2.9	48.4–60.0
(Farkas, 1981)	7	50	54.0	2.4	49.2–58.8
	8	51	55.0	3.0	49.0–61.0
	9	50	56.0	3.3	49.4–62.6
	10	49	56.2	2.9	50.4–62.0
	11	51	55.8	3.6	48.6–63.0
	12	53	57.4	3.6	50.2–64.6
	13	49	58.5	3.9	50.7–66.3
	14	51	57.4	3.3	50.8–64.0
	15	51	57.9	3.5	50.9–64.9
	16	51	57.9	2.8	52.3–63.5
	17	51	59.0	3.6	51.8–66.2
	18	51	58.5	3.4	51.7–65.3

Ear width (Tables 2.3 and 2.4) grew more slowly than ear length. It increased only about 15 percent during 20 years, while the body increased 400 percent in the same period. *Ear insertion width* is reported in Table 2.5. Increase of the ear insertion was slow and was only a few millimeters between 6 and 19 years of age.

TABLE 2.3. Width of left ear in healthy Caucasian males.

Population norm	*Age*	N	*Mean* ($\bar{x}$) (*mm*)	*SD*	*Range of normal* ($\bar{x}$ − 2 *SD*)–($\bar{x}$ + 2 *SD*)
German	6 mo	18	28.7	2.0	24.7–32.7
(Hajniš, 1974)	1 yr	27	30.3	2.2	28.1–32.5
	2	32	31.5	2.5	26.5–36.5
	3	55	31.6	2.4	26.8–36.4
	4	77	32.7	2.6	30.1–35.3
	5	70	32.9	2.3	28.3–37.5
North American Caucasian	6 yr	50	33.9	2.2	29.5–38.3
(Farkas, 1981)	7	50	34.3	2.3	29.7–38.9
	8	51	34.7	2.2	30.3–39.1
	9	51	34.9	2.1	30.7–39.1
	10	50	35.4	2.4	30.6–40.2
	11	50	34.6	2.5	29.6–39.6
	12	52	35.2	2.3	30.6–39.8
	13	50	35.7	2.0	30.7–39.7
	14	49	35.3	2.5	30.3–40.3
	15	50	35.8	2.1	31.6–40.0
	16	50	35.3	2.8	29.7–40.9
	17	49	35.9	2.2	31.5–40.3
	18	52	35.4	2.2	31.0–39.8

TABLE 2.4. Width of left ear in healthy Caucasian females.

Population norm	*Age*	N	*Mean* ($\bar{x}$) (*mm*)	*SD*	*Range of normal* ($\bar{x}$ − 2 *SD*)–($\bar{x}$ + 2 *SD*)
German	6 mo	29	27.8	2.3	23.2–32.4
(Hajniš, 1974)	1 yr	25	30.1	1.5	27.1–33.1
	2	28	30.4	1.7	27.0–33.8
	3	47	30.2	2.1	26.0–34.4
	4	66	31.8	2.3	27.2–36.4
	5	69	31.2	2.3	26.6–35.8
North American Caucasian	6 yr	50	33.0	1.7	29.6–36.4
(Farkas, 1981)	7	50	33.2	1.7	29.8–36.6
	8	51	33.3	2.1	29.1–37.5
	9	50	33.1	1.9	29.3–36.9
	10	49	33.6	2.0	29.6–37.6
	11	51	32.8	2.4	28.0–37.6
	12	53	33.7	2.3	29.1–38.3
	13	49	33.3	2.2	28.9–37.7
	14	51	32.4	1.7	29.0–35.8
	15	51	33.3	1.9	29.5–37.1
	16	51	33.1	2.2	28.7–37.5
	17	51	33.2	2.7	27.8–38.6
	18	51	33.5	2.1	29.3–37.7

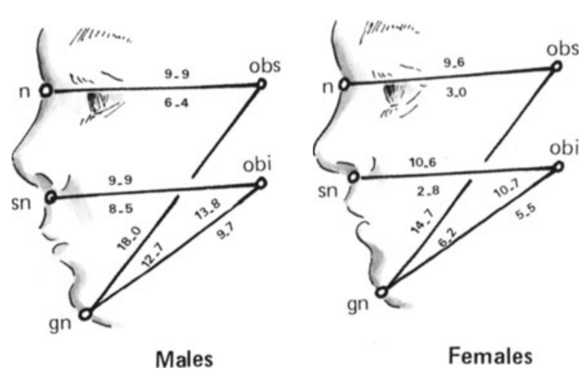
TABLE 2.5. Ear insertion width in North American Caucasians.

			Width of insertion morphological width: OBS–OBI of ear						
			Right				*Left*		
Age group (years)	*Sex*	N	*Mean* $\bar{x}$ *(mm)*	*SD*	*Range of normal* ($\bar{x}$ − 2 *SD*)–($\bar{x}$ + 2 *SD*)	N	*Mean* $\bar{x}$ *(mm)*	*SD*	*Range of normal* ($\bar{x}$ − 2 *SD*)–($\bar{x}$ + 2 *SD*)
6–7	Boys	27	41.5	2.7	36.1–46.9	27	42.4	2.8	36.8–48.0
	Girls	29	41.2	3.4	34.4–48.0	29	41.2	3.4	34.4–48.0
12–13	Boys	45	45.6	3.1	39.4–51.8	45	45.5	3.4	38.7–52.3
	Girls	43	46.3	2.9	40.5–52.1	43	46.7	3.1	40.5–52.9
18–19	Boys	34	50.2	3.9	42.4–58.0	34	50.2	4.2	41.8–58.6
	Girls	17	48.5	4.6	39.3–57.7	17	48.9	4.5	39.9–57.9

It was slightly less in girls than in boys. There was almost no difference between the two sides.

Ear Geography. The *ear location* was measured between the auricular insertion points (obs, obi) and the *facial middle landmarks* (n, sn, gn) (Figalová and Farkas, 1968) and recorded in Table 2.6. All measurements showed faster growth between 6 and 12 years of age than in the following 6-year period, as the illustration demonstrates.

Maximum growth was between menton and otobasion superius, in both sexes during the 6- to 12-year span, and also this measurement was the fastest during the overall time (30.7 mm in boys, 20.9 mm in girls). The slowest growth in males was between nasion and otobasion superius (6.4 mm), but in females it was between subnasale and otobasion inferius (2.8 mm). Similarly, the slowest overall finding was n to obs (16.3 mm in boys and 12.6 mm in girls).



Growth measurements in millimeters are above the lines for 6–12 years of age and below the lines for 12–18 years (left side)

TABLE 2.6. Position of left ear assessed by the aid of the ear insertion points and the landmarks of the face in North American Caucasians.

Age group (years)	Sex	N	Distance between the nasan root (n) and the ear upper insertion point (obs): Mean $\bar{x}$ (mm)	SD	Range of normal $(\bar{x} - 2\ SD)$–$(\bar{x} + 2\ SD)$	Distance between the columella base (sn) and ear lower insertion point (obi): Mean $\bar{x}$ (mm)	SD	Range of normal $(\bar{x} - 2\ SD)$–$(\bar{x} + 2\ SD)$	Distance between the chin point (gn) and ear upper insertion point (obs): Mean $\bar{x}$ (mm)	SD	Range of normal $(\bar{x} - 2\ SD)$–$(\bar{x} + 2\ SD)$	Distance between the chin point (an) and the ear lower insertion point (obi): Mean $\bar{x}$ (mm)	SD	Range of normal $(\bar{x} - 2\ SD)$–$(\bar{x} + 2\ SD)$
6–7	Boys	50	104.1	4.3	95.5–112.7	95.6	4.3	87.0–104.2	127.3	5.3	116.7–137.9	94.1	4.0	86.1–102.1
	Girls	50	101.0	4.9	91.2–110.8	93.6	3.7	86.2–101.0	125.7	5.2	115.3–136.1	93.1	4.0	85.1–101.1
12–13	Boys	52	114.0	5.2	103.6–124.4	105.5	4.8	95.9–115.1	145.3	5.5	134.3–156.3	107.9	5.2	97.5–118.3
	Girls	53	110.6	4.4	101.8–119.4	104.2	4.5	95.2–113.2	140.4	5.8	128.8–152.0	103.8	5.5	92.8–114.8
18–19	Boys	52	120.4	6.1	108.2–132.6	113.0	5.2	102.6–123.4	158.0	7.5	143.0–173.0	117.6	6.5	104.6–130.6
	Girls	51	113.6	5.8	102.0–125.2	106.9	4.2	97.1–116.7	146.6	6.3	134.0–159.2	109.3	5.6	98.1–120.5

TABLE 2.7. Location of the left ear canal on the head in North American Caucasians.

Age group (years)	Sex	Distance of ear canal (porion) from: Apex of head (vertex) (v–po): N	$\bar{x}$ (mm)	SD	Range of normal $(\bar{x} - 2\ SD)$–$(\bar{x} + 2\ SD)$	Most posterior point of head (opisthion) (op–po): N	$\bar{x}$ (mm)	SD	Range of normal $(\bar{x} - 2\ SD)$–$(\bar{x} + 2\ SD)$
6–7	Boys	50	128.6	5.9	116.8–140.4	31	89.3	6.8	75.7–102.9
	Girls	50	125.4	4.9	115.6–135.2	36	87.6	5.7	76.2–99.0
12–13	Boys	52	132.8	5.2	122.4–143.2	50	93.3	5.7	81.9–104.7
	Girls	53	130.1	5.8	118.5–141.7	50	92.0	4.0	84.0–100.0
18–19	Boys	52	136.9	5.9	125.1–148.7	50	95.3	5.1	85.1–105.5
	Girls	51	130.1	5.4	119.3–140.9	38	93.7	5.5	82.7–104.7

Ear location measured by *landmarks on the head* is reported in Table 2.7. The left half of the table shows data about the distance projected vertically from the ear canal to the vertex, and the right half establishes the horizontal distance from the canal to the opisthion. Both had a faster increase during the 6- to 12-year period (about 4 mm in both sexes) than the following period, during which it slowed down to about half (2 mm). Only the vertex–ear canal measurement in males increased similarly in both periods and was slightly more than in females. Canal–opisthion figures differed minimally in either sex.

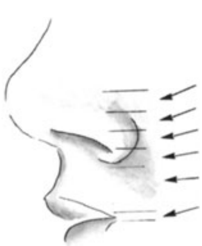
Ear level was determined by *tragi location.* Asymmetrical tragi level may indicate asymmetrically located ears or ear canals in the vertical plane. In the North American Caucasian population asymmetrical tragi level was 13.4 percent.

TABLE 2.8. Upper level of the left ear related to the eyebrow in North American Caucasians.

6–7				*12–13*				*18–19*			
Boys (50)		*Girls (60)*		*Boys (52)*		*Girls (53)*		*Boys (52)*		*Girls (51)*	
N	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
11	22.0	7	14.0	10	19.2	8	15.1	13	25.0	11	21.2
14	28.0	11	22.0	18	34.6	22	41.5	26	50.0	13	25.0
24	48.0	27	54.0	22	42.3	20	37.7	12	23.1	27	51.9
0	0.0	4	8.0	1	1.9	0	0.0	0	0.0	0	0.0
1	2.0	1	2.0	1	1.9	1	1.9	0	0.0	1	1.9

(Age group (years))

TABLE 2.9. Lower level of the left ear related to the nasal ala in North American Caucasians.



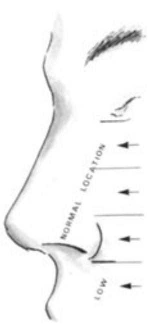
6–7				*12–13*				*18–19*			
Boys (50)		*Girls (50)*		*Boys (52)*		*Girls (53)*		*Boys (52)*		*Girls (51)*	
N	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
0	0.0	1	2.0	0	0.0	0	0.0	0	0.0	0	0.0
1	2.0	1	2.0	0	0.0	2	3.8	0	0.0	1	2.0
16	32.0	12	24.0	18	34.6	23	43.4	22	42.3	20	39.2
3	6.0	3	6.0	6	11.5	6	11.3	9	17.3	5	9.8
30	60.0	33	66.0	28	53.4	20	37.7	20	38.5	26	51.0
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0

(Age group (years))

Tables 2.8 and 2.9 report the level of the *upper and lower left ear edges.* In the majority of cases, the upper edge was level with the tail of the eyebrow, with the exception of young male adults, where the level was just above it. A "low" location, with the upper aural edge on a level with the eyelid, was rare and found mainly in the younger age groups. A "high" location, with the upper ear edge above the eyebrow's highest point, was seen more frequently with maturity. In elderly persons it is useful to use the upper orbital margin as a reference because it is more constant than the eyebrow, as the soft tissue may sag and become ptotic.

None of the normals in the reported age groups had a very low location of the low ear edge, on a level with the labial commissure. Mostly, the lower aural edge was level with the upper lip. This rather unprecisely defines lower ear edge location, because the upper lip is a wide area (average: 15–20 mm high) and may indicate both relatively high or low locations upon it.

TABLE 2.10. Left ear canal level related to the middle face (Leiber, 1972) in North American Caucasians.



	Age group (years) 6–7 Boys (N = 50)	6–7 Girls (N = 50)	12–13 Boys (N = 52)	12–13 Girls (N = 53)	18–19 Boys (N = 52)	18–19 Girls (N = 51)	*Total* (N = 308)
N	1	0	3	4	8	1	17
%	2.0	0	5.8	7.5	15.4	2.0	6.5
N	9	13	23	22	28	35	130
%	18.0	26.0	44.2	41.5	53.8	68.6	42.2
N	31	34	25	25	15	11	141
%	62.0	68.0	48.1	47.2	28.8	21.6	45.8
N	1	0	0	0	0	1	2
%	2.0	0	0	0	0	2.0	0.6

In the last century, some anatomists (Langer, 1882, 1884; Holl, 1899) had already recognized the fact that ear level could be determined objectively by assessing the *position of the ear canals.* Table 2.10 shows the result of this measurement. Of 308 subjects examined in the three selected age groups, only 2 had low set ears: a 6-year-old boy and an 18-year-old girl. But 5 individuals were observed with bilateral, and 8 with unilateral (5 right and 3 left), low ear location (13.1 percent) when the entire North American Caucasian population sample ($N = 1{,}312$) was analyzed. Low placement is classified as a true minor defect. High ear location was seen in 1 boy (unilateral) and 1 girl (bilateral), 0.2 percent.

Our study shows that within the "normal" zone of the face, there is a marked shifting of the ear canal level between 6 and 18 years of age. At 6 years, the canal level was usually in the lower part of the "normal" zone at the nasal ala, while at the end of facial growth, the canal level was higher, mostly in the midorbitonasal zone.

Inclination of the longitudinal ear axis is shown in Table 2.11. Ear inclination refers to the *vertical* and was slightly more in girls at 6 years of age. In the following two age groups, however, there was more inclination in boys. There were minimal differences between measurements taken at 6 and 18 years, without a persistent trend.

TABLE 2.11. Inclination of medial longitudinal axis of the left ear in North American Caucasians.

Age group (years)	Sex	N	Inclination in degrees measured from the vertical $\bar{x}$	SD	$(\bar{x} - 2\ SD)$–$(\bar{x} + 2\ SD)$
6–7	Boys	50	19.5	5.0	9.5–29.5
	Girls	49	20.1	6.5	7.1–33.1
12–13	Boys	52	21.8	4.9	12–31.6
	Girls	53	18.2	5.4	7.4–29.0
18–19	Boys	52	20.0	5.0	10.0–30.0
	Girls	51	18.4	4.8	8.8–28.0

Results of *ear protrusion* are given in Table 2.12. There was negligible difference of ear protrusion from the head between 6 and 18 years in both sexes. There was almost no difference between the right and left sides. Ears protruding over 40 degrees were slightly more in females (5.2 percent) than males (3.9 percent). The overall frequency of prominent ears was 4.5 percent. The maximum degree of protrusion was 50 degrees.

TABLE 2.12. Protrusion of the ears from the head in North American Caucasians.

Age group (years)	Sex	N	Ear protrusion (in degrees) Right ear $\bar{x}$	Right ear SD	Left ear $\bar{x}$	Left ear SD	Outstanding ears N	%	Maximum extent
6–7	Boys	50	21.6	6.5	22.8	7.3	3	6.0	50°
	Girls	50	19.9	6.1	19.9	5.8	2	4.0	40°
12–13	Boys	52	21.7	6.1	21.9	6.4	2	3.9	45°
	Girls	53	22.0	6.9	21.9	6.3	3	5.7	40°
18–19	Boys	52	22.9	5.4	23.0	5.5	1	1.9	40°
	Girls	51	23.2	7.8	22.3	6.6	3	5.9	50°
	Total	308					14	4.6	

Relationship between Some Measurements of the Face and Ear

Confronting two measurements with a mathematical formula can reveal very interesting details. For example, the relationship between two *vertical measurements*, the combined height of the head and face (v–gn) and the distance between the apex of the head and the ear canal (v–po) may be seen in Table 2.13. Growth was four times faster in vertex–menton than vertex–porion. The relationship between the measurements showed a slight shift only when the ear canal was well below the horizontal line, half way between the vertex and menton at 6 years of age, and it became higher in position by 18 years of age. This finding explains the so-called migration of the ears to a higher position in adults, compared to children. The index gradually decreased toward adulthood, with great similarity between boys and girls.

TABLE 2.13. Relationship between the apex of the head–menton distance (*A*) and the apex of head–left ear canal distance (*B*) in North Amercan Caucasians.

Age group (years)	Sex	A Apex of the head (v–gn) N	A Apex of the head (v–gn) Mean ($\bar{x}$) (mm)	B Apex of the head (v–po) left N	B Apex of the head (v–po) left Mean ($\bar{x}$) (mm)	Index $\frac{B \times 100}{A}$ %
6–7	Boys	50	198.2	50	128.6	64.9
	Girls	50	194.0	50	125.4	64.6
12–13	Boys	52	218.2	52	132.8	60.9
	Girls	53	216.1	53	130.1	60.2
18–19	Boys	52	234.3	52	136.4	58.2
	Girls	51	216.2	51	130.1	60.2

The relationship between two *horizontal measurements,* the length of head (g–op) and the distance between the back point of the head and the ear canal (op–po) is shown in Table 2.14. The ear canal was localized slightly behind the vertical line, drawn half way between the glabella and opisthion, at 6 years of age in both sexes. At 12 years there was some movement toward the midline. The ear canal reached the vertical midline in girls, but in boys it remained slightly behind. This situation was constant until the end of growth.

TABLE 2.14. Relationship between the head length (*A*) and the distance between the left ear canal and back point of the head (*B*) in North American Caucasians.

Age group (years)	Sex	A Length of head (g–op) N	A Length of head (g–op) Mean ($\bar{x}$) (mm)	B Ear canal left (po–op) N	B Ear canal left (po–op) Mean ($\bar{x}$) (mm)	Index $\frac{B \times 100}{A}$ %
6–7	Boys	50	183.2	31	89.3	48.7
	Girls	50	177.7	36	87.6	49.3
12–13	Boys	52	188.8	50	93.3	49.4
	Girls	53	184.2	50	92.0	49.9
18–19	Boys	52	192.7	50	95.3	49.5
	Girls	51	184.9	38	93.7	50.7

We studied the relationship between the inclination and length of the *nose* and ear. The vast majority of young North American Caucasians (91.1 percent) had the nasal dorsum more inclined (average 30.8 degrees) than the left ear (average 18 degrees), which was more upright. They were only parallel in 5 men and 4 women out of 101. The average difference between these inclinations was 9 degrees in boys and 10 degrees in girls. This situation changes minimally with age, with a tendency to become more upright. A recent study (Skiles and Randall, 1983) confirms our finding about the difference between the inclination of the nasal bridge and the ear. Also the overwhelming majority (95.1 percent) had the nose shorter than the left ear. In only 2 men and 3 women out of 103 young adults were they of equal length (Farkas, 1983).

Ethnic Differences in Anthropometry of the Face and Ears

Anthropologists (e.g., Hajniš, 1974) recognize certain typical characteristics for various Caucasian ethnic groups. For surgeons, the significance of these findings would be most valuable if the differences between them could be demonstrated in a simple and illustrative manner (Coon, 1948; Nuñez and Herrera, 1970; Crosby, 1973; Millard, 1973; Figalová and Smahel, 1975; Rogers, 1974b). The American and Canadian Caucasian population is heterogenous, composed of a number of ethnic groups, but even the proportions of these groups vary from one region to another. Our study followed the official distribution of Caucasian ethnic groups in Canada, and thus the findings are a mixture of qualities typical for the individual nationalities. Tables 2.15–2.17 show some differences

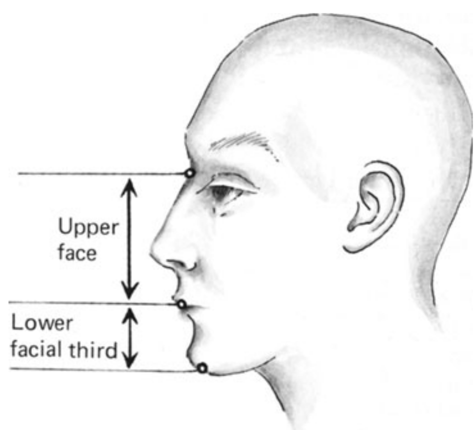
TABLE 2.15. Lengths of upper and lower third of the face in three Caucasian populations.

Age group	*Population*	*Sex*	Upper face length (*n–sto*) N	*Mean*	*SD*	*Differences* (t-*test*)	*Lower third face length* (*sto–gn*) N	*Mean*	*SD*	*Differences* (t-*test*)
6–7	CZ	M	51	61.1	3.5	*Czech girls* have significantly longer upper face than *American girls* (t = 0.02–0.01). The remainder of the comparisons are without significant difference.	52	37.2	3.2	*North American boys and girls* have significantly longer lower third of face than *Czechs* (t < 0.001).
		F	53	59.6	3.1		53	36.6	3.7	
	GE	M	61	60.4	3.0			data not available		
		F	57	59.0	2.8					
	AM	M	50	60.0	3.5		50	41.4	3.2	
		F	50	57.9	3.5		50	40.3	3.3	
12–13	CZ	M	54	68.8	3.8	*Czech boys* have a significantly longer upper face than the *Germans* or *Americans* (t = 0.05–0.02). *German girls* have significantly longer upper face than the *American girls* (t = 0.02–0.01).	54	41.4	4.2	*North American boys and girls* have significantly longer lower third of face than the *Czechs* (t < 0.001).
		F	56	66.6	3.2		56	41.6	3.1	
	GE	M	61	67.4	3.8			data not available		
		F	61	67.5	2.9					
	AM	M	52	67.1	4.1		52	44.1	3.9	
		F	51	66.1	3.0		53	44.1	3.6	
18–19	CZ	M	57	72.5	3.9	*North American boys* have significantly longer upper face than the *Czechs* (t = 0.005–0.02).	57	45.9	4.0	*North American boys and girls* have significantly longer lower third of face than the *Czechs* (t < 0.001).
		F	58	68.1	3.3		56	43.7	3.7	
	GE	M	40	73.8	3.9			data not available		
		F	24	68.9	3.7					
	AM	M	51	74.2	4.0		52	50.1	4.4	
		F	52	68.1	3.4		51	45.2	2.9	

Note: CZ = Czech, GE = German; Am = North America.

between the face and ear in the Czech (Hajniš and Dobisiková, 1968a, 1968b), West German (Hajniš, 1974), and North American Caucasians (Farkas, 1981). The following summarizes the findings.

1. *Proportions between the upper face and lower facial third.* In physical anthropology the section marked as the "upper face" (upper half of the face) anatomically includes the entire area located between the nasal root level and the labial fissure line, and the "lower third of the face" is represented anatomically by the central portion of the lower jaw. The upper face height is the rectilinear distance between the nasal root (nasion) and the point between the closed lips in the midline (stomion). The height of the lower third of the face is the rectilinear distance between the stomion and the chin point (gnathion or menton). Both are measured with a sliding caliper.

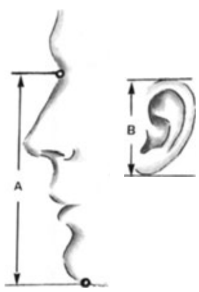


Anthropological division of the facial profile

In the first two age groups in Table 2.15, the upper face of the North American Caucasian boys or girls was significantly shorter than those of the Czechs or Germans. The upper face in the North American boys became considerably longer at 18–19 years of age, however, compared to the Czech boys. The lower third of the face was significantly longer in North American Caucasian boys and girls compared to the Czechs in all reported age groups.

2. *Relationship between ear length and facial height.* The relationship between the face height and left ear length (Table 2.16) at 6 years of age was moderately different in the three Caucasian populations. The ear occupied progressively less space (from 59 percent to 51 percent) when related to the face. This was caused

TABLE 2.16. Relationship of ear length to the morphological height of the face in males of three Caucasian populations.



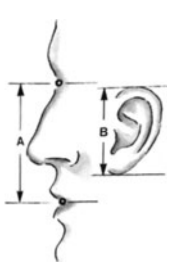
Age group (years)	*Population (males only)*	N	A *Height of face (n–gn) Mean (mm)*	B *Length of left ear (sa–sba) Mean (mm)*	*Index* B × 100 / A (%)
	Czech	52	98.4	55.8	56.7
6–7	German	61	95.4	56.5	59.2
	N. American	50	98.5	55.0	55.8
	Czech	48	109.0	59.7	54.7
12–13	German	61	107.3	60.9	56.8
	N. American	52	109.1	59.1	54.2
	Czech	57	118.5	63.4	53.5
18–19	German	61	118.6	63.5	53.5
	N. American	52	121.3	62.4	51.4

by slower (about twice as slow) ear growth compared to the rate of vertical facial growth during the 6- to 12-year period. While facial growth kept pace in the following 12- to 18-year period, ear growth slowed down. This trend was common in all three populations. The face of the North American Caucasian boys was longer in relation to the left ear than in Continental Europeans.

3. *Relationship between ear length and upper face height.* Table 2.17 shows moderately decreasing index values with age in all three populations. At 6 years of age, the left ear occupied over 90 percent of the upper face height; at the end of the development, ear lengths covered 84.3–87.4 percent of the upper face area, with the smallest index in North American Caucasian boys, which indicates a relatively small ear among the three populations.

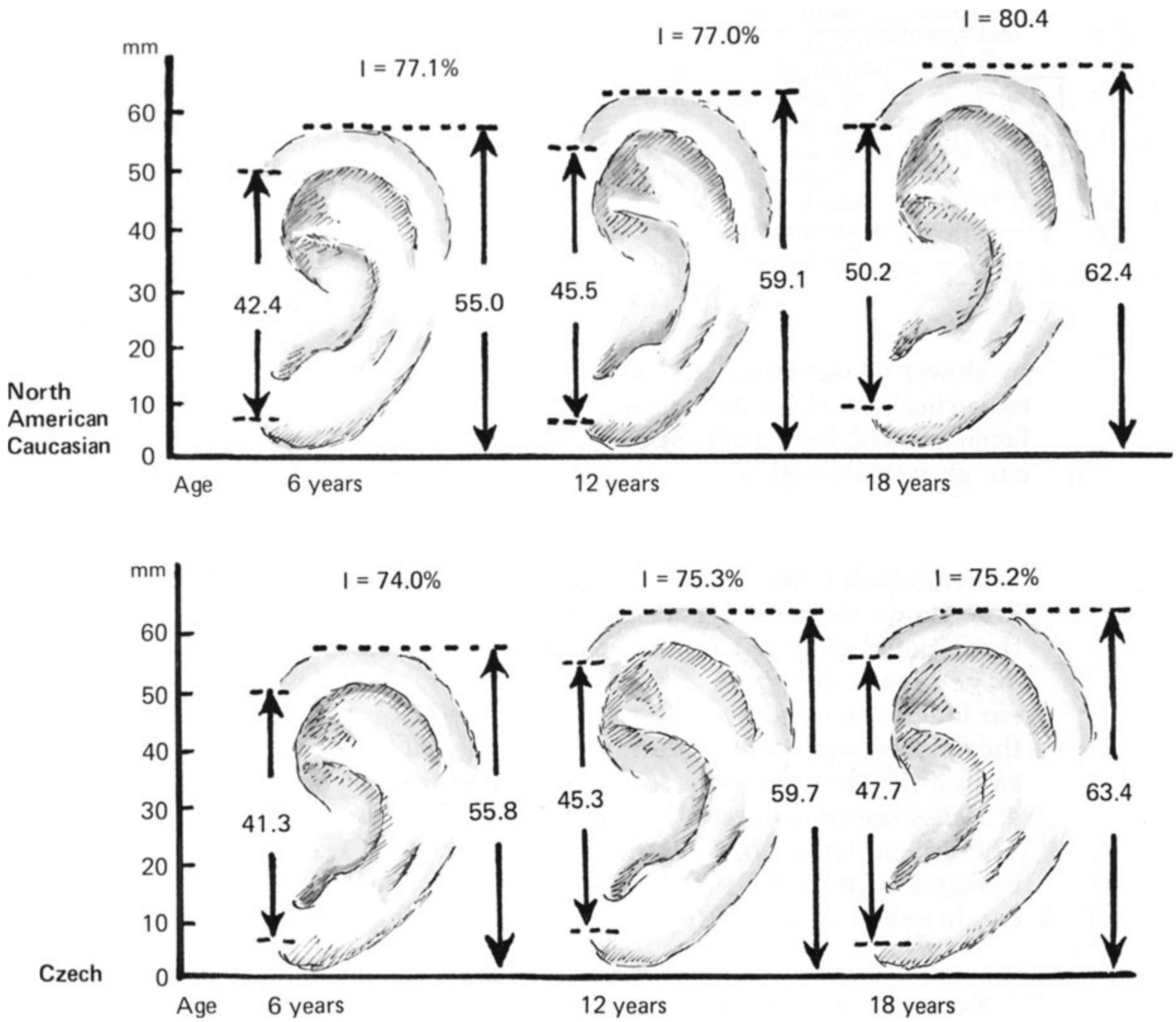
4. *Relationship between the ear insertion width and the ear length.* The left ear length in Czech and North American Caucasian boys is very similar in the three selected age groups. The width of the ear insertion gradually increases with the growth of the ear in

TABLE 2.17. Relationship of ear length to the height of the upper face in males in three Caucasian populations.



Age group (years)	*Population (males)*	N	A *Height of upper face (n–sto) Mean (mm)*	B *Length of left ear (sa–sba) Mean (mm)*	*Index* G × 100 / A (%)
	Czech	51	61.1	55.8	91.3
6–7	German	61	60.4	56.5	93.5
	North American	50	60.0	55.0	91.6
	Czech	54	68.8	59.7	86.8
12–13	German	61	67.4	60.9	90.4
	North American	52	67.3	59.1	87.8
	Czech	57	72.5	63.4	87.4
18–19	German	61	73.8	63.5	86.0
	North American	51	74.0	62.4	84.3

both populations. The index values show that in North American Caucasian boys the insertion width occupies a slightly larger portion of the ear length than in Czech boys.



The relationship between the left ear insertion width (A) *and the left ear length* (B)*—index* = (A × *100*)/B*—compared in North American Caucasian and Czech boys of three age groups*

In spite of our limited knowledge about the ethnic differences between the main Caucasian groups, we feel that striking dissimilarities of form and size in the face are rare. It is our opinion that these ethnic differences in ear morphology and geography cannot significantly influence the surgical planning of otoplasty, as they are minimum—only a few millimeters or degrees—as demonstrated by these reports.

Disfigurements

Qualitative Ear Signs

Only the most obvious disfigurements have been recorded (Table 2.18) in the North American Caucasian population (Farkas, 1981). Disfigurations of the general shape of the ear are rare. The most frequent defect we found was an abnormally wide helical rim, found in the upper two-thirds of the ears. The defects were almost equally distributed in the right and left sides. The overall number of girls with defective ears was greater (51) than boys (43) in the 306 persons examined in the recorded three age groups. Ear defects gradually became less frequent in the boys between 6 and 19 years of age (40–17.6 percent), while in girls they increased (28–40.4 percent).

TABLE 2.18. Frequency of ear disfigurements in North American Caucasians between 6 and 18 years of age.

Feature	*Uni- or bilateral disfigurement*	N	%
Helix	Wide helix	192	14.6
	Wide and thin helix-covering scapha	67	5.1
	Helix impression at junction of vertical and horizontal ear portions	45	3.4
	Unfolded (flat) helix	6	0.5
General ear shape	Cup ear	1	0.1
	Cercopithecus-type shape	1	0.1
	Marked disfigurement of helix contour	3	0.2
Lobule	Hypoplasia	16	1.2
Preauricular area	Skin appendage	2	0.2

Defective ears were often bilateral. In the 6- to 7-year age group, bilateral defects were found in 36 percent of the boys and 26 percent of the girls. However, in 18- to 19-year-olds, they dropped to 13.7 percent in boys but increased to 33.3 percent in girls. In a few people with bilateral ear involvement, the defect differed in quality on the right and left sides.

It is interesting that the number of persons we found with unilaterally affected ears increased with age. In the 6- to 7-year age group, it was 2 percent for both sexes, while at 18–19 years, the number increased to 5.9 percent in boys and 11.8 percent in girls. The defective ear was equally frequent on either side in the 6- to 7-year age group, but at 18–19 years, the left side was affected twice as often as the right.

Most of the recorded "defects" can be qualified as variations of normal. The cup ear (J. E. Davis, 1974a; Rogers, 1974a), the hypoplastic lobule, and the preauricular tag (F. Altmann, 1950b) have been classified as minor anomalies (Rogers, 1974b). We regard the flat unfolded helix as anomalous; it can occur alone or in combination with a change in shape of the whole ear (macacus, cercopithecus) (Farkas and Lindsay, 1973). The concave variations of the auricular contour illustrated previously as a helical impression, and first reported in cleft lip palate patients (Hajniš and Farkas, 1968), has been catalogued as a minor defect. This is questionable. This special ear deformity was observed in 3.4 percent of North American Caucasians and was more frequent in girls.

Ear Asymmetries

It is well known that variations of shape and size are frequent between one ear and the other (Hasse; G. V. Webster, 1969). To obtain precise data for these asymmetries, it is necessary to compare their frequency and quality with healthy normals, as established in our series with North American Caucasians (Farkas, 1981).

Asymmetries in Ear Size. Among ear *length* and *width* asymmetries, more asymmetrically long ears (21.9 percent) were observed than width asymmetries (18 percent). Asymmetrically long ears were more frequent in boys (23.2 percent) than girls (20.6 percent), while ear width asymmetries were found more often in girls (19.3 percent) than boys (16.7 percent). The maximum difference between the asymmetrically long ears was 6 mm, and between asymmetrically wide ears it was 7 mm.

Table 2.19 shows that asymmetrically long ears become less frequent with age in both sexes. Ear width asymmetries increase with age in males and decrease in females. Age does not change the average differences (3–4 mm) between the ears of unequal length or width. Total size asymmetries of the ears (one ear shorter and narrower than the other) were less frequent (8.5 percent) in these groups, and more frequent in boys (9.7 percent) than in girls (7.2 percent).

Asymmetries of ear *insertion* width were very frequent (48 percent), with a maximum difference of 7 mm. This asymmetry was

TABLE 2.19. Ear size asymmetries in North American Caucasians.

			Individuals with ear asymmetries in:							
Age group (years)	*Sex*	N	*Length only* N	%	*Width only* N	%	*Both width + length* N	%	*Total* N	%
6–7	Boys	50	13	26.0	9	18.0	4	8.0	26	52.0
	Girls	50	15	30.0	14	28.0	2	4,0	31	62.0
12–13	Boys	52	12	23.1	11	21.2	7	13.4	30	57.7
	Girls	53	7	13.2	11	20.8	5	9.4	23	43.4
18–19	Boys	52	11	21.2	12	23.1	4	7.6	27	51.9
	Girls	50	13	26.0	6	12.0	4	7.8	23	46.0

more frequent in girls (49.5 percent) than in boys (46.6 percent), with similar average differences in both sexes (between 2.3 and 3.3 mm). Table 2.20 shows that greater asymmetries of ear insertions were more frequent with age in both sexes. The average differences in both sexes were stable in the registered age groups (about 3 mm). Greater insertion was more frequent on the left side.

TABLE 2.20. Asymmetries in width of insertion of the ears in North American Caucasians.

Age group (years)	*Sex*	N	*Individuals with asymmetrical insertion widths of ears* N	%
6–7	Boys	28	12	42.9
	Girls	29	8	27.6
12–13	Boys	45	16	35.6
	Girls	43	21	48.8
18–19	Boys	34	16	47.1
	Girls	17	11	64.7

Asymmetries in Ear Location. Differences in projected distances between the *ear insertion points* (otobasion superius and inferius) and the *facial midline landmarks* (gnathion, subnasale, and nasion) constitute ear location asymmetries. Those between the *chin point* (gn) and *ears' upper insertion point* (obs) were more frequent (68.5 percent) than those between *menton* (gn) and the *ears' lower insertion point* (obi) (55.5 percent). These asymmetries were more frequent in boys (gn–obs: 70.2 percent, gn–obi: 56.7 percent) than girls (gn–obs: 66.9 percent, gn–obi: 54.3 percent). The maximum absolute difference of 11 mm was found between the menton and the ear's lower insertion point. Between the menton and the ears' upper insertion point the maximum difference was 10 mm. Average differences were similar: slightly less in gn–obi (3.2 mm) than in gn–obs (3.6 mm) asymmetries. The left side measurements were usually longer than the right. With age, asymmetrical menton–upper insertion distances were less frequent in both sexes (Table 2.21). Menton–lower insertion distances, to the contrary, tended to increase with age.

Asymmetries in distances between the *nasal root* (n) and the *ears' upper insertion points* (obs) were more frequent (63.6 percent) than those between the *columella base* (sn) and the *lower insertion* (obi) distances (55.1 percent). The maximum absolute difference found between the right and left n–obi was 12 mm (in a 6-year-old boy), and between the right and left sn–obi was 10 mm (in a 14-year-old girl). The average difference was very close (n–obs: 3.5 mm, sn–obi: 3.2 mm) in both asymmetries.

TABLE 2.21. Asymmetries in position of insertion points of the ears related to landmark of lower third of the face in North American Caucasians.

		Individuals with asymmetries between:					
		Right and left menton–ears' upper insertion point (obs) projection distance			*Right and left menton–ears' lower insertion point (obi) projective distance*		
Age group (years)	Sex	N	n	%	N	n	%
6–7	Boys	50	35	70.0	50	26	52.0
	Girls	50	34	68.0	50	28	56.0
12–13	Boys	52	34	65.4	52	26	50.0
	Girls	53	37	69.8	53	27	50.9
18–19	Boys	52	28	53.9	52	30	57.7
	Girls	51	34	66.7	51	35	68.6

There was no sex difference in frequency of n–obs asymmetries (both sexes 63.8 percent) or the average differences (both sexes 3.5 mm). The absolute maximum difference was greater in boys (12 mm) than girls (9 mm). More males had sn–obi asymmetries than females (57.3 percent versus 52.9 percent). The nasion–ear's upper insertion distances were greater on the right side, while the columella base–ears' lower insertion distances were greater on the left side. Table 2.22 shows that age did not significantly influence the frequency of upper face (n–obs) and midface (sn–obi) asymmetries in either sex.

TABLE 2.22. Asymmetries in position of insertion points of the ears related to the upper and middle face landmarks in North American Caucasians.

		Individuals with asymmetries between:					
		Right and left nasal root (nasion)–ears' upper insertion point (obs) projective distance			*Right and left columella base (subnasale)–ears' lower insertion point (obi) projective distance*		
Age group (years)	*Sex*	N	n	%	N	n	%
6–7	Boys	50	29	58.0	50	23	46.0
	Girls	50	34	68.0	50	30	60.0
12–13	Boys	52	33	63.5	52	34	65.4
	Girls	53	42	79.2	53	32	60.4
18–19	Boys	52	30	57.7	52	29	55.8
	Girls	51	36	70.6	51	30	58.8

Asymmetries between the ears' insertion points and the face midline landmarks are not detectable if average or mild. They become visible if greater than 1 cm. Asymmetries were more frequent between the upper ear insertion and the nasal root or the menton, than between the lower ear insertion and the columella base or menton. This can be explained by common deviations of the chin point from the midline and by frequent asymmetrical inclination of the longitudinal ear axis. The upper insertion of an ear that is more inclined becomes located farther back from the facial midline.

Among assymmetries between the *ear edge levels* and the *orbital* and *nasolabial level,* 42.8 percent of the upper edges, the lower edges, or both did not level with the same features on either side of the face. Asymmetrical ear edges were slightly more frequent in boys (43.1 percent) than girls (42.6 percent). In children between 6 and 12 years of age, the asymmetrical ear edge levels were more common (44.4 percent) than in the 12- to 18-year age group (41.5 percent). Asymmetries of the upper edge level were markedly more frequent than those of the lower edge. The level difference is well determined by referring to the orbital features (eyebrow, eyelid, eye canthus) that are all well defined and placed close to the ear; but the lower ear margin is referred mostly to the wide area of the upper lip and is less precise.

Among horizontal and vertical asymmetries of the *ear canal,* vertical asymmetry was 2.5 times more frequent (18.5 percent) than the horizontal (7 percent). The average differences in these asymmetries were negligible (po–op: 3.6 mm, v–po: 3.5 mm). The maximum absolute difference was greater in horizontal (12 mm) than in vertical asymmetries (9 mm). A slight horizontal asymmetry of the ear canal could not be detected visually in healthy subjects. The auricle with the greater vertical measurement (v–po) may appear to be low set provided the other ear is in high normal location. Greater vertical measurements (between the vertex and porion) were more frequent on the right side, while the left ear was more frequently anteriorly shifted. Both asymmetries had a declining trend with age.

Horizontal asymmetries were more frequent in males (8.5 percent) than females (5.5 percent), with greater average difference in males (3.8 mm) compared to females (3.4 mm). Similarly, the vertical ear canal asymmetries were more frequent in males (19.8 percent) than females (17.2 percent), but the average difference was greater in females (3.7 mm) than males (3.2 mm). Greater vertical measurements (v–po) were found slightly more often on the right side, and thus the right ear canal was the lower one. Horizontal asymmetries of the ear canal, placing one ear more forward, showed the left ear to be more frequently anteriorly shifted.

There was a temporary increase in vertical asymmetries in both sexes at 12–13 years of age (Table 2.23), and much less at 6 and 18 years of age. The horizontal asymmetries had a declining trend toward the oldest age group. A horizontal asymmetry of the ear

TABLE 2.23. Asymmetries in ear canal location in vertical and horizontal level in North American Caucasians.

		Individuals with asymmetries in ear canal position					
		Horizontally (po–op)			*Vertically (v–po)*		
Age group (years)	*Sex*	N	n	%	N	n	%
6–7	Boys	31	4	12.9	50	6	12.0
	Girls	36	0	0	50	2	4.0
12–13	Boys	50	3	6.0	52	17	32.7
	Girls	50	1	2.0	53	15	28.3
18–19	Boys	50	1	2.0	52	7	13.5
	Girls	38	1	2.6	51	5	9.8

canal could barely be detected visually, but a greater vertical measurement created the impression of a low set ear.

Asymmetries of Ear Level. Asymmetries in *tragus* levels were relatively rare (13.4 percent). The tragion was lower on the left side twice as often as on the right. This asymmetry increased temporarily at the age of 12 years, then declined, and it was more frequent in boys than girls.

Asymmetries of *ear canal* levels (Leiber test, modified by Farkas) were found in 1.1 percent of this series. Low canals were recorded bilaterally in 5 individuals (3 boys and 2 girls) and unilaterally in 8 subjects (5 boys and 3 girls). The right auricle was more often low set (5) than was the left (3). The two high set ears were unilateral (1 boy) and bilateral (1 girl). The frequency of ear canal asymmetries decreased with age in both sexes.

Asymmetries in Ear Inclination. In this series 51 percent of the ears were asymmetrically inclined, slightly more in girls (52.5 percent) than boys (50.2 percent). The average difference was of 4.6 degrees, and the maximum absolute difference was 15 degrees in boys and 11 degrees in girls. Greater ear inclinations were more common on the left side. The frequency of asymmetrical ear inclination decreased slightly with age in boys but remained unaltered in girls (Table 2.24).

Asymmetries in Ear Protrusion. Almost one-third (31.8 percent) had asymmetrical ear protrusions. The average difference was 5.7 degrees, but the maximum absolute difference reached 22 degrees. This asymmetry was more common in boys (34.8 percent) than girls (28.9 percent), with an identical average difference (5.7 degrees) in both sexes. Greater protrusion was found more often on the left side. Table 2.25 shows that in boys, after peaking at age 12, the frequency of asymmetries decreased at 18 years of age. In girls, no significant changes were observed in the same period.

TABLE 2.24. Asymmetries in inclination of the medial longitudinal axis of ears in North American Caucasians.

Age group (years)	Sex	N	Individuals with asymmetrical ear inclination to vertical n	%
6–7	Boys	50	22	44.0
	Girls	49	22	44.9
12–13	Boys	52	23	44.2
	Girls	53	19	35.8
18–19	Boys	52	20	35.8
	Girls	50	22	44.0

TABLE 2.25. Asymmetries in protrusion of the ear in North American Caucasians.

Age group (years)	Sex	N	Individuals with asymmetrical ear protrusion n	%
6–7	Boys	50	15	30.0
	Girls	50	12	24.0
12–13	Boys	52	23	44.2
	Girls	53	12	22.6
18–19	Boys	52	20	38.5
	Girls	51	13	25.5

Asymmetry of the Face

Among the basic measurements of the face, the horizontal surface arcs taken from one tragus (t) through the base of the columella (sn) to the tragus on the opposite side, and from one tragus through the chin (gn) to the other, supply information about the surface symmetry of the right and left halves of the face. Any asymmetry between the halves of these arcs, caused primarily by a jaw defect, will consequently influence some ear measurements, and vice versa, a malpositioned or defective ear will influence the surface arch measurements. Anatomically, the right and the left subnasale–tragion half arcs are mostly in the maxillary region, and the gnathion–tragion semiarcs follow the mandible.

The frequency of *mandibular* surface asymmetries was significantly greater (70.7 percent) than the *maxillary* surface asymmetries (57.6 percent). The average difference was 4.0 mm in the mandibular asymmetries and 3.4 mm in the maxillary, differences that are visually not obvious and with the right side usually the larger. Projective measurements between the same points of the maxilla and mandible gave very similar results (Farkas and Cheung, 1981).

Maxillary asymmetries were significantly more frequent in boys (61.5 percent) than girls (53 percent), with similar average differences in both sexes (males: 3.5 mm, females: 3.3 mm), but with the maximum absolute difference of 13 mm (in a 14-year-old girl). Mandibular asymmetries were not significantly more frequent in boys (72 percent) than girls (69.3 percent), with an almost identical average difference (4.0–3.9 mm) and the same maximum absolute difference in both sexes (13 mm). In our experience, only asymmetries exceeding 10 mm are visually detectable. Age did not significantly influence these asymmetries (Table 2.26).

TABLE 2.26. Asymmetries of the face: Differences in the surface maxillary and mandibular half-arcs in North American Caucasians.

Age group (years)	Sex	N	*Individuals with asymmetries in:* *Maxillary half-arcs (rt and lt, sn–t)* n	%	*Mandiular half-arcs (rt and lt, gn–t)* n	%
6–7	Boys	50	24	48.0	32	64.0
	Girls	50	24	48.0	30	60.0
12–13	Boys	52	34	65.4	41	78.8
	Girls	53	29	54.7	34	64.2
18–19	Boys	52	28	53.8	38	73.1
	Girls	51	31	60.8	36	70.6

The Use of Anthropometry in Patients with Ear Defects

Ear defects associated with deformity of the face caused by congenital anomaly or trauma may lead to dislocation of some of the facial landmarks or to difficulties in identifying them. Consequently, this influences the degree of precision of the surface measurements. Visible defects are marked on a simple diagram of the face, both in frontal and lateral (right and left) views (Kazanjian and Converse, 1949). This will show whether the defects are uni- or bilateral, in balance or unbalanced (Hellman, 1939).

In *mild* unilateral asymmetry of the face, ear, or both, the opposite "normal" side will determine the extent of the surgical repair. In congenital anomalies, sometimes even the apparently unaffected side may not be normally developed (Farina et al., 1960).

In a *moderate* unbalanced bilaterally defective face or in a *severe* unilateral or severely unbalanced bilateral defect of the face, the degree of asymmetry and the extent of disproportion must be determined both cephalometrically and anthropometrically. The harmony of the face must be restored prior to reconstruction of the defective ear. It is easier to build a new ear in a location determined by surface measurements than to depend only on the aesthetic instinct of the surgeon.

The minimum requirement is that the ears should be located between the horizontals touching the eyebrow and the nasal ala, and just behind the midpoint along the length measurement (g–op) of the head. The generally accepted average ear size is 60 mm in length and 30 mm in width in older children and adults.

The index for ear width/length—(pra–pa × 100)/sa–sba—showed a gradual moderate age-related elongation, that is, narrowing of the auricles (61.4 mm at 6 years of age, 59.3 mm at 12 years, and 57.8 mm at 18 years).

Ear Reconstruction and Asymmetry

The aim of reconstructive or aesthetic surgery is not to rebuild the face and ears into mathematically perfect features but to obtain a natural looking face. Irregularities and asymmetries created by the surgeon must not, however, exceed those found in the average normal face. Mild asymmetries cannot be detected visually. The following conclusions were reached in this study:

1. *Ear size.* A 5-mm difference in length and 3- to 4-mm difference in width are not obvious under routine observation. True ear length cannot be judged visually. In daily practice, the size of the ear is estimated by the location of the upper and lower ear edges as related to various features of the upper and lower face. An ear of normal length, but narrower than normal, looks longer than it is in reality.

2. *Ear location.* In the horizontal plane, the constructed ear should be placed approximately in the same area of the head as the ear on the opposite side. In normal 6-year-old boys, the area "covered" by the smallest ear (4.8 cm long, 2.8 cm wide) was about 10.5 cm^2. A moderate horizontal dislocation (about 7 mm) of the pinna forward or backward cannot be detected at routine examination if the two sides of the face are approximately symmetrical.

The place of attachment of the new ear must be carefully determined when the ipsilateral side of the face is much narrower. To obtain a more acceptable visual impression from the front, ear insertion must be shifted behind the vertical lateral midline of the skull. Thus, the balance of distance between the facial midline and each ear will improve when viewed from the front, even though the new ear will appear retropositioned from the back.

In our observations of normals, moderate vertical asymmetries at the level of the auditory meatus (about 5 mm) cannot be discovered visually.

3. *Ear level.* Ear level is especially observed by eye in relation to the eyebrows and nasal alae. The level of the upper and lower ear edges must be examined both from front and back views. In our experience, an asymmetrical ear level when examined from the front is much more obvious at the lower edge than the upper. This is probably because anteriorly placed earlobes and narrower contours of the lower half of the face will allow a more accurate estimation of symmetry.

4. *Ear inclination.* The newly formed ears must have a similar inclination of their medial longitudinal axis. Upright position (0 degrees to the vertical plane) is unnatural. Any inclination between 10 degrees and 20 is acceptable. Greater inclination makes the ear appear shorter and creates the impression of low set ears, because the upper edge of a tilted ear, when related to the other features of the face, becomes situated lower than normal. The

inclination of the unilaterally reconstructed ear should follow the inclination of the opposite ear. It is difficult to see the difference between two tilted ears, but the asymmetry becomes obvious if one of them is upright.

5. *Protrusion.* A certain protrusion is a standard requirement for a good-looking reconstructed ear. In correcting a unilateral ear defect, the protrusion of both ears should be similar. Again, a difference of approximately 5 degrees is not obvious. A new auricle which appears to be "stuck" to the head is unnatural. To have the impression of natural ear protrusion, a minimum 10-degree protrusion from the head should be achieved. In patients with a unilateral ear defect, greater protrusion of the normal ear can be decreased by surgery to improve symmetry.

The surgeon cannot be guided only by strict measurements. He must also understand the principles of beauty of form, to enable him to restore the balance of nature which most pleases the eye.